Claims

[c1] 1.A substrate coating apparatus comprising:

a deposition chamber adapted to be maintained at subatmospheric pressure;

support means in said deposition chamber for a substrate, said substrate having at least one surface; and

a set of expanding thermal plasma generating means associated with said deposition chamber, said generating means being adapted to deposit a coating on said substrate, said set comprising at least two of said means and all of said means in said set being codirectionally oriented.

[c2] 2.The apparatus according to claim 1, wherein the expanding thermal plasma generating means are wall-stabilized DC arc generators.

[c3] 3.The apparatus according to claim 1, wherein said expanding thermal plasma generating means are within said deposition chamber.

[c4] 4.The apparatus according to claim 1, wherein said expanding thermal plasma generating means are outside but in communication with said deposition chamber.

[c5] 5The apparatus according to claim 1, further comprising a movement actuator adapted to move the substrate support means past said set of expanding thermal plasma generating means.

[c6] 6.The apparatus according to claim 1, wherein the substrate support means is a hook, frame, arm or clamp.

[c7] 7.The apparatus according to claim 1, wherein the substrate support means is a flat panel adapted to provide support for the entire substrate.

[c8] 8.The apparatus according to claim 1, further comprising a shutter in said deposition chamber between said substrate support and said expanding thermal plasma generating means, said shutter containing one or more apertures configured so as to allow overlapping of adjacent plasma plumes but block the low power edge portions of said streams.

[c9] 9.The apparatus according to claim 3, wherein the expanding thermal plasma generating means are in a straight line parallel to the plane of motion of the substrate support means, and with the center axes of the plasma plumes produced by said expanding thermal plasma generating means oriented perpendicular to the plane of motion of the substrate support means.

[c10] 10.The apparatus according to claim 3, wherein the expanding thermal plasma generating means are in a zigzag configuration in a plane parallel to the plane of motion of the substrate support means, and with the center axes of the plasma plumes produced by said expanding thermal plasma generating means oriented perpendicular to the plane of motion of the substrate support means.

[c11] 11.The apparatus according to claim 10, wherein the angle between successive lines leading from one expanding thermal plasma generating means to the next is in the range of 10-80 °.

[c12] 12.The apparatus according to claim 1, further comprising at least one temperature control means located and adapted to heat or cool substrate regions spaced from the center axes of the expanding thermal plasma generating means.

[c13] 13.The apparatus according to claim 12, wherein said temperature control means are heating means.

[c14] 14.The apparatus according to claim 12, wherein said temperature control means are located on either side of and between the expanding thermal plasma generating means.

[c15] 15.The apparatus according to claim 14, wherein said temperature control means are located upstream, with respect to movement of the substrate support means, from the expanding thermal plasma generating means.

[c16] 16.The apparatus according to claim 1, wherein the expanding thermal plasma generating means are located such that the anodes thereof are at a distance of 20-40 cm from the substrate.

[c17] 17.The apparatus according to claim 16, wherein the expanding thermal plasma

generating means are spaced so that their center axes are about 10-21 cm apart.

[c18] 18.The apparatus according to claim 1, wherein the apparatus comprises a plurality of sets of expanding thermal plasma generating means, located to deposit coatings on more than one side of a substrate.

[c19] 19.The apparatus according to claim 1, wherein the apparatus comprises a plurality of sets of expanding thermal plasma generating means, located to deposit successive coatings on a substrate.

[c20] 20.The apparatus according to claim 1, wherein the locations and configurations of said expanding thermal plasma generating means are adapted to deposit a coating on a curved substrate.

[c21] 21.The apparatus according to claim 1, wherein the apparatus comprises a plurality of deposition chambers and sets of expanding thermal plasma generating means, for deposition of plural coating layers on a substrate.

[c22] 22.A substrate coating apparatus comprising:
a plurality of deposition chambers, each of said chambers adapted to be maintained at subatmospheric pressure;
support means adapted to convey a substrate through said deposition chambers in succession;
a movement actuator adapted to move said substrate support means and substrate through said deposition chambers in succession;
a plurality of sets of expanding thermal plasma generating means associated with said deposition chambers, said generating means being adapted to deposit a coating on said substrate, each of said sets comprising at least two of said means and all of said means in each of said sets being codirectionally oriented; said generating means in each set being oriented in a straight line or a zigzag configuration, said line or configuration being parallel to the plane of motion of the substrate support means, and said generating means being located such that the anodes thereof are at a distance of about 20-40 cm from the substrate and spaced so that their center axes are about 10-21 cm apart; and

heating means located and adapted to heat substrate regions spaced from the center axes of said generators.

[c23] 23.The apparatus according to claim 22, wherein a plurality of sets of expanding thermal plasma generating means are located to deposit coatings on more than one side of a substrate.

[c24] 24.A method for coating a substrate, the method comprising generating a set of at least two expanding thermal plasma plumes to produce plasma enhanced chemical vapor deposition or PECVD of a coating on said substrate, each of said plumes in said set being codirectionally oriented.

[c25] 25.The method according to claim 24, wherein the substrate is a thermoplastic substrate.

[c26] 26.The method according to claim 25, wherein the thermoplastic is a polycarbonate.

[c27] 27.The method according to claim 24, wherein the plasma is an argon or argon-oxygen-organosiloxane plasma.

[c28] 28.The method according to claim 27, wherein the coating is silica-based.

[c29] 29.The method according to claim 24, wherein the substrate is moved past at least one set of expanding thermal plasma generating means.

[c30] 30.The method according to claim 24, wherein substrate regions spaced from the center axes of expanding thermal plasma generating means producing said coating are heated prior to or simultaneously with the coating operation.

[c31] 31.The method according to claim 24, wherein a plurality of sets of plasma plumes is generated to deposit coatings on more than one side of said substrate.

[c32] 32.The method according to claim 24, wherein a plurality of sets of plasma plumes is generated to deposit successive coatings on said substrate.

[c33] 33.The method according to claim 24, wherein the substrate is planar.

[c34] 34.The method according to claim 24, wherein the substrate is curved.

[c35] 35.A method for coating a polycarbonate substrate, the method comprising generating a plurality of sets of at least two expanding thermal plasma plumes to produce successive coatings on said substrate while moving said substrate past said sets of plumes, each of said plumes in said set being codirectionally oriented; said coatings being silica-based and the plasmas being argon or argon-oxygen plasmas.

[c36] 36.An article coated by the method of claim 24.